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STUDIES OF HERBICIDE SENSITIVITY IN THE UPTAKE OF DIFFERENT IONS BY RICE ROOTS

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Abstract

A study was made of the effect of SYNPRAN 111 herbicide on the uptakes of potassium, phosphate, nitrate and ammonium ions by rice roots. The isotopically-labelled uptake solution contained different concentrations of SYNPRAN 111, which is 30,6% 3,4-dichloropropionanilide + +8,0% 2, 4, 5-trichlorophenoxyacetic acid amyl ester. It was proved that at 10^{-4} M herbicide concentration potassium and nitrate ion uptakes were at first effectively inhibited, while on 10^{-6} M herbicide treatment the effects were not injurious, but rather favourable. In general it can be stated that potassium and nitrate nitrogen uptakes are more sensitive towards herbicide treatment than phosphate or ammonium nitrogen uptakes. The toxic or stimulatory effect of SYNPRAN 111, however, was also notably influenced by the concentration and temperature of the uptake solution, showing the importance of environmental factors in herbicide action.

Introduction

It has long been well known that ion uptake by plants is fairly strongly influenced by some environmental factors, e.g. temperature, pH, aerobic or anaerobic conditions, etc. (FRIED et al. 1965 LEWIS-WORKMAN 1964, SUTCLIFFE 1962, ZSOLDOS 1967, 1972). Recently it was also established that some practically-employed, biologically-active substances, e. g. herbicides, fungicides, etc., similarly have effects on the ion uptakes and mineral nutritions of plants. From the literature data it is clear that the concentration of the herbicide or fungicide plays a very important role in its effect. In general, treatment with higher herbicide concentrations is toxic, whereas a low concentration very often has a favourable effect (CHESALIN-TIMOFEJEVA 1968, FREAR-SHIMABUKURO 1970, HAUNOLD-ZSOLDOS 1976, MORELAND 1967, ZSOLDOS 1974). The investigations further indicate that several compounds may help to produce not only a higher yield, but a better quality too (IRRI Ann. Rep. 1970—1972, JAISWAL et al. 1973).

Recently it was proved that the effects of herbicides are likewise considerably influenced by certain environmental factors, e. g. temperature, nutrient concentration, etc. The experimental results similarly show that ion transport responds differently towards herbicide treatment (HAUNOLD-ZSOLDOS 1976, HILTON-JANSEN 1963, NODA-IBARAKI 1968).

From the above literature data it is clear that herbicides and fungicides not only control weeds and blasts, but can also modify the mineral nutrition and in this way the yields of plants. As different biologically-active compounds are widely employed in agriculture, we feel that special attention must be paid to this double effect of

herbicides in the future. For this reason, ion uptake experiments have been carried out with different ions to examine the effects of herbicide treatment and some environmental factors.

Materials and Methods

The potassium, phosphate, nitrate and ammonium ion uptakes of excised rice roots (*Oryza sativa* L. cv. Dunghan Shali) were investigated at different concentrations of SYNPRAN 111 herbicide. Seeds were disinfected, rinsed in running tap water for 6 hours, and allowed to germinate on filter paper in Petri dishes. The seedlings were grown under standard conditions as described earlier (ZSOLDOS 1972, 1974).

6—8-day-old plants were used in the further experiments, their roots then being about 7—8 cm long. Before the start of a short-time ion uptake experiment, the roots were excised and immediately washed for 10 minutes in distilled water. The samples were then placed in 500 ml aerated, isotopically-labelled uptake solution containing different concentrations of SYNPRAN 111 (a product of the Budapest Chemical Works, Hungary), which is 3, 4-dichloropropionanilide (30,6%) and the amyl ester of 2, 4, 5-trichlorophenoxy-acetic acid (8,0%). In the following, the concentration values given refer to the pure active ingredient.

The potassium uptake studies were carried out in 10^{-3} M K(^{86}Rb) Cl + 5×10^{-4} M $CaSO_4$ solution. The phosphate ion uptake was studied from 10^{-4} M or 10^{-3} M $KH_2{}^{32}PO_4$ solution, the isotope contents of experimental material being measured with a scintillation counter. The uptakes of nitrate and ammonium ions from 10^{-3} M NH_4NO_3 or $NaNO_3$ solution were studied with the help of ^{15}N, using a mass-spectrometer for the determination of nitrogen uptake as described earlier by PROKSCH (1969).

The ^{15}N concentration of the $^{15}NH_4NO_3$ was 70 atom per cent, and of the $Na^{15}NO_3$ was 95 atom per cent (a product of the VEB Berlin Chemie). The pH of the uptake solution was adjusted to 6,5 and was checked again after the incubation. The root samples were removed from the solution after a one-hour or 80-min uptake period, and were washed three times for one minute. The isotope contents of the samples were measured as mentioned above. The results are given in μmole ion uptake/g dry weight or atom % ^{15}N excess as a percentage of the control (untreated). Data are means of three replications in all the experiments.

Results and discussion

1. Uptakes of different ions: The potassium, phosphate, nitrate and ammonium ion uptakes characteristic of herbicide treatment at different concentrations are visible in the graphs of Fig. 1 and 2. The experimental results clearly indicate that potassium and nitrate ions were more sensitive towards SYNPRAN 111 herbicide treatment than phosphate or ammonium ions.

In connection with the nitrogen uptake, it is noteworthy that the ammonium ion is taken up 8—10 times faster than the nitrate ion. As to the K ion uptake the absorption rate of potassium is about 7 times as great as that of phosphate ion.

From the data it can also be seen that at lower herbicide concentration there is a slight stimulatory effect too (except for the phosphate ion). Although the differences between the ion uptakes of the control (untreated) and the herbicide-treated samples are not very large, they are reproducible. At a SYNPRAN 111 concentration of 10^{-5} M a slight inhibitory effect can be observed (except for the ammonium ion), while at 10^{-3} M the active ion uptake practically ceases.

These data unambiguously confirm that, although the effects of the herbicide are considerably influenced by its concentration, the sensitivities of different ions to the herbicide treatment vary appreciably. In our opinion these experimental results

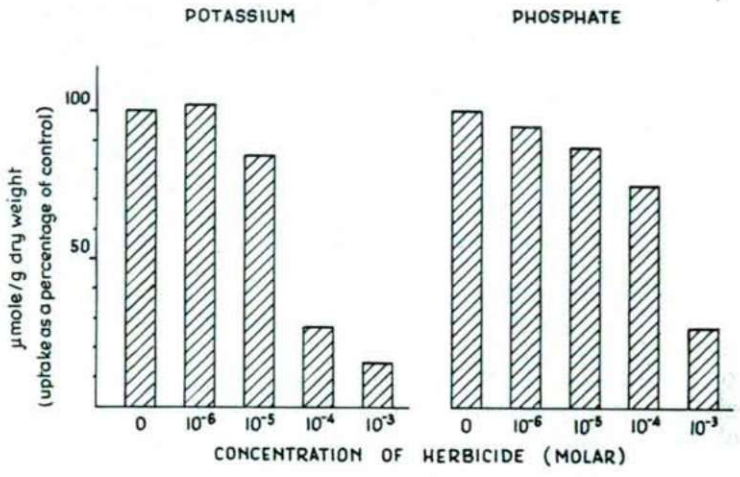

Fig. 1. The effects of different herbicide concentrations on the uptakes of potassium from 10^{-3} M KCl solution and phosphate from 10^{-3} M KH_2PO_4 solution by rice roots. Uptake time: 60 minutes.

show, among others, the practical importance of such an investigation, as the toxic or enhancing effect of herbicides on ion uptake and mineral nutrition, as already mentioned, can also modify the yields of plants.

2. Influence of some environmental factors on theeffect of herbicide treatment. As seen in Fig. 3, the effect of herbicide treatment on the ion uptake varies to a certain extent with the concentration and temperature of the uptake solu-

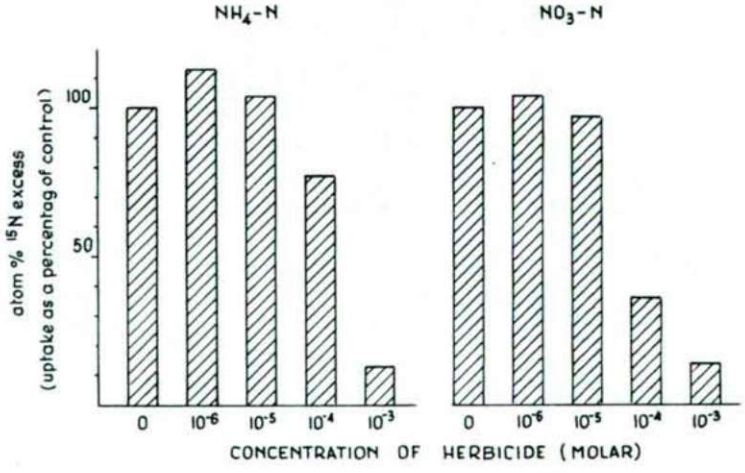

Fig. 2. The effects of different herbicide concentrations on the uptakes of ammonium from 10^{-3} M NH_4NO_3 solution and nitrate from 10^{-3} M $NaNO_3$ solution by rice roots. Uptake time: 80 minutes.

tion. The experimental data show that at lower herbicide concentrations a slight stimulatory effect is found with 10^{-4} M uptake solution for phosphate too, whereas such an effect is not detectable with 10^{-3} M uptake solution.

These results are rather surprising, especially if we consider the two mechanisms of ion uptake described earlier (EPSTEIN 1972).

Similarly noteworthy effects are induced by lower and higher temperatures, as revealed by the graphs of Fig. 3. The experimental data clearly indicate that at lower temperature the SYNPRAN 111 herbicide has a stronger effect on the ion uptake than at 30 °C. It is worth mentioning that, for example, in the case of wheat under these experimental conditions the temperature effects are just opposite to those for rice (unpublished data). This is not so surprising, however, if we think of the difference between the ion uptakes of thermophilic (rice) and non-thermophilic (wheat) plants (ZSOLDOS, 1972).

Low temperature in itself has an unfavourable effect on the ion uptake as well known from our earlier experimental data (ZSOLDOS 1972): The total ion uptake is naturally always significantly higher at 30 °C than at 14 °C. In our case the difference is about 50 per cent.

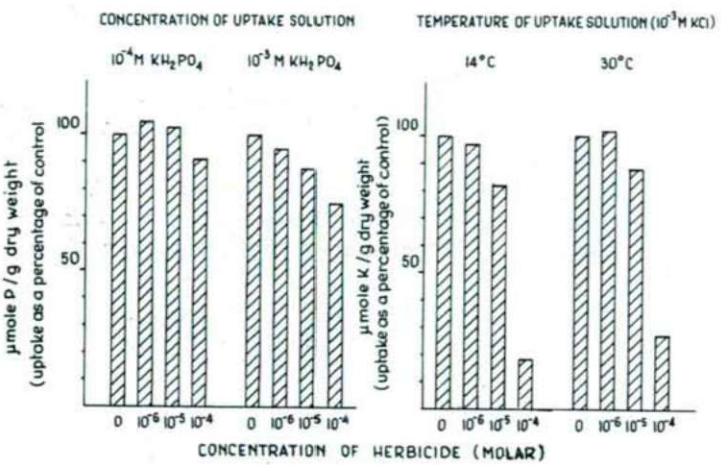

Fig. 3. The effects of the concentration and temperature of the uptake solution on the phosphate and potassium ion uptakes during different herbicide treatments. Uptake time: 60 minutes.

To summarize, it is seen from the above data that the well-known classical environmental factors, e.g. temperature and nutrition concentration, could have special effects on the mineral nutrition of herbicide-treated plants. It is obvious, therefore, that close attention must be paid to the interaction which exists between mineral nutrition, herbicide treatment and some environmental factors. These must be taken into consideration in practice too, before or during herbicide treatment, and on the use of fertilizers.

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